PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RSJ08045WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/GB2004/005035	International filing date *(day/month/year)* 01.12.2004	Priority date *(day/month/year)* 02.12.2003
International Patent Classification (IPC) or national classification and IPC G01N21/35		
Applicant CITY TECHNOLOGY LIMITED et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 9 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 6 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☒	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☒	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
30.09.2005	28.12.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Verdoodt, E Telephone No. +31 70 340-3577

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/005035

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1-24	as originally filed
Claims, Numbers	
1-41	filed with telefax on 30.09.2005
Claims, Pages	
26, 27	filed with telefax on 02.12.2005
Drawings, Sheets	
1/2, 2/2	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/005035

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
   - ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
   - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☒ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:

   see separate sheet

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	5-41
	No:	Claims	1-4
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-41
Industrial applicability (IA)	Yes:	Claims	1-41
	No:	Claims	

2. Citations and explanations (Rule 70.7):

   see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

   and / or

2. Non-written disclosures (Rule 70.9)

   see separate sheet

Re Item II

Priority

The present application claims priority of GB0327931, filed December 2, 2003. With regard to claims 6-11, 12-15, this priority has been found to be invalid, as certain features disclosed in these claims were not disclosed in the priority document.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: DE 203 01 081 U1 (DRAEGER SAFETY AG & CO. KGAA) 10 April 2003

D2: WO 2004/023113 A (E2V TECHNOLOGIES LIMITED; HOPKINS, GRAHAM, PAUL) 18 March 2004

D3: WO 02/077619 A (EDWARDS SYSTEMS TECHNOLOGY INC ; KOUZNETSOV ANDRIAN I (US)) 3 October 2002

D4: DE 201 21 183 U1 (STEINEL GMBH & CO. KG) 3 April 2003

D5: US-A-5 475 222 (KING JOHN D) 12 December 1995

D6: GB-A-2 116 317 (HORIBA LTD) 21 September 1983

D7: US-A-3 614 431 (MCHENRY THOMAS F) 19 October 1971

D8: US-B1-6 410 918 (KOUZNETSOV ANDRIAN I) 25 June 2002

D9: GB-A-2 372 099 (DYNAMENT LTD) 14 August 2002 (

D10: US-B1-6 469 303 (HSI PETER C ET AL) 22 October 2002

Claim 1: Clarity (Art. 6 PCT)

1.1 The application does not meet the requirements of Article 6 PCT, because claim 1 is not clear.

1.2 Claim 1 does not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The claim attempts to define the subject-matter in terms of the results to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

1.3 The results to be achieved are:

1) to make sure that the cavity is substantially uniformly illuminated with radiation, and

2) to make sure that the visible surface area of the detector is illuminated with substantially unfocussed radiation.

1.4 According to claim 1, these results are dependent on how reflective the walls of the cavity are. In the words of claim 1, they are "sufficiently reflective" for these results to be achieved.

1.5 However, it is clear, also from the description (I.e. p. 7, l. 3-7), that the form of the cavity is an important parameter to achieve uniform illumination: E.g. a very long cavity would clearly not provide uniform illumination throughout its volume. Further, the fact that the visible surface area of the detector is illuminated with unfocussed radiation, is the result of the absence of any lenses, mirrors or other focussing elements, like the walls themselves. In case of specular reflecting surfaces, the positioning of the radiation source and detector with regard to each other also plays a role.

1.6 In fact, according to the description (p. 4, l. 2-5), the intention of the design of the cavity is to avoid imaging of the source and to produce uniform illumination in the region occupied by the detector: Not only the surface reflectivity of the walls of the cavity, but also the form of the cavity is therefore an essential feature which should be present in the independent claims.

Claim 1: Novelty (Art 33(2) PCT)

2.1 Furthermore, in case the above mentioned results to be achieved are neglected and the walls of the cavity are interpreted as being reflective to the radiation, so that radiation may be reflected several times before reaching the detector, the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT, and therefore the criteria of Article 33(1) PCT are not met.

2.2 Document D8 (US-6410918-B1) discloses (the references in parentheses applying to this document):
A gas sensor (200) comprising a cavity (specularly reflective waveguide = 202) for containing a gas; means (203) for generating radiation which is transmitted through the cavity and including one or more wavelengths which is absorbed in use by a gas to be detected; and a detector (205) for detecting radiation which has passed through the cavity, the detector having a surface area which is visible to the interior of the cavity, wherein the radiation generating means and detector are mounted on a printed circuit board (214) and is surrounded by resilient protection (201) (See column 5, lines 33-34).

2.3 The housing (201) may be made of plastic. Clearly plastic has a certain resilience. The lower part of the housing (201), having an upper surface (206), surrounds the detector and light source and provides therewith resilient protection to the detector and light source.

2.4 Claim 1 is therefore not new in the sense of Article 33(2) PCT.

Claim 12: Clarity

3.1 Claim 12 comprises the essential feature regarding the form of the cavity. Yet, like in claim 1, it is not clear how reflective the walls of the cavity are. Claim 12 is therefore also not clear (Art. 6 PCT) with regard to this feature.

3.2 In order to be able to examine at least independent claim 12 in detail, the results to be achieved will be neglected, and the walls of the cavity will be interpreted as being reflective for the radiation, so that radiation may be reflected several times by the walls before reaching the detector.

Claim 12: Inventive step

4.1 Furthermore, the above-mentioned lack of clarity notwithstanding, the subject-matter of claim 12 does not involve an inventive step in the sense of Article 33(3) PCT, and therefore the criteria of Article 33(1) PCT are not met. Document D1 discloses (the references in parentheses applying to this document):

4.2 A gas sensor comprising
- a cavity (3) for containing a gas;
- means for generating radiation (6) which is transmitted through the cavity and including one or more wavelengths which is absorbed in use by a gas to be detected;
- a detector (23,24) for detecting radiation which has passed through the cavity;
- the walls of the cavity being reflective to the radiation (Page 2, line 28- page 3, line 8 and page 3, line 32 - page 4, line 6), wherein the cavity is tubular, for example cylindrical, and has substantially planar end walls (1,5), adjacent to at least one of which, the means for generating radiation and the detector is positioned and wherein the ratio of height to the width of the cavity is from about 1 to 3 (See claim 1, part c): "die Höhe der Messgasküvette entspricht etwa dem einfachen bis dreifachen Durchmesser der Deckelemente").

4.3 The subject-matter of claim 12 therefore differs from this known D1 in that:

the ratio of height to the width of the cavity is greater than or equal to 0.1 and less than or equal to 0.7.

4.4 The problem to be solved by the present invention may therefore be regarded as how to make a gas sensor which has a low height, in order for it to fit in narrow spaces.

4.5 A close look at the possible objective problem solved by a flat, cylindrical cavity shows that the cavity dimensions are merely a design feature and that there is no technical effect arising from reducing the height of the cavity. The reasoning for this is as follows:

4.6 As acknowledged in the description (See page 7, line 5-7), an integrating sphere provides the best uniformity of light throughout its cavity. As they are expensive to produce, a cylinder is taken as cavity to approximate the sphere. (Page 5, l. 7-10) Obviously, the best approximation exits when the dimensions, that is the height to width ratio, are as equal in all dimension as possible. (See also page 8, lines 17-20) A ratio for the height to width of 1 is thus the best approximation.

4.7 According to the description, "the extent to which this is achievable is modified by practical considerations." (See also page 8, l. 20-22) In other words, for practical reasons, the cavity is chosen to have a smaller height in comparison to its width, without any technical problem being solved by this parameter. There is no technical effect being exhibited by using a flat cylindrical cavity. The only reason for this choice is to make the whole gas sensor flat and therefore compact in a vertical direction, in order e.g. to fit in narrow spaces.

4.8 Obviously, flat cavities are free from the tendency exhibited by long, thin cavities to bundle radiation towards the centre of their circular cross-section. (See also page 8, lines 15-17) However, the cavity disclosed by D1 is not long and thin, but shows an even dimension in height and width.

4.9 In case the skilled problem was faced with the problem of lack of space in the vertical direction in the spot where a gas sensor is to be installed, he would think of reducing the cavity dimension of the cavity of the gas sensor of D1, in this direction, which results in a flat cavity, having a cavity with a height which is less than its width.

4.10 Hence, no inventive step is present in the subject-matter of claim 12.

Claim 40: Inventive step

5.1 Claim 40 will now be considered as referring only to claim 12 and dependent claims,

and not claim 1 and dependent claims, because of the missing essential features in claim 1.

5.2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 40 does not involve an inventive step in the sense of Article 33(3) PCT.

5.3 The document D1 is regarded as being the closest prior art to the subject-matter of claim 40, and discloses (the references in parentheses applying to this document):
A method of constructing a gas sensor according to claim 12 and dependent claims, comprising:
- inserting a radiation source and detector into a tubular electronics housing (5), the electronics housing having an end wall closed at one end except for one or more apertures to allow access to the source and detector;
- mating the electronics housing with the a tubular optical housing, closed by a wall (1) at one end except for at least one gas access aperture ((Page 5, line 16), so that it defines therewith a substantially closed optical cavity between the end walls of the electronics and optical housings and in which a gas to be sensed is located in use; and
- securing the assembled housings together (obvious in D1).

5.4 The subject-matter of claim 40 therefore differs from this known D1 in that:
- a tubular outer housing is provided, in which the optical and electronics housings are inserted, the outer housing being closed at its end adjacent the closed end of the optical housing, except for at least one gas access opening, and
- the radiation source and detector are mounted on a printed circuit board.

5.5 The problem to be solved by the present invention may therefore be regarded as
- how to provide protection of the optical and electronics housings, and
- how to facilitate the construction when inserting the radiation source and detector.

5.6 The solution proposed in claim 40 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the following reasons.

5.7 Document D5 (US-5475222) as well as D8 (US-6410918-B1) show a gas sensor which is provided with an outer housing to provide protection. In D5, this is indicated with reference numeral (10), and in D8 with (207). Both outer housings are designed to have a similar shape as the housings that they protect and to provide holes for the gas to flow through, towards the openings in the optical housing.

5.8 Document D8 also shows a printed circuit board (214) on which the radiation source

and detector are mounted, in order to facilitate construction when inserting them into the lower half of the housing (See also column 6, lines 7-12).

5.9 The features mentioned in 5.4 are thus described in documents D5 and D8 as providing the same advantages as in the present application. The skilled person would therefore regard it as a normal option to include these feature in the method of constructing the gas sensor as described in document D1 in order to solve the problems posed.

Dependent claims 2-11, 13-39, 41

6.1 In claims 2-11, 13-39, 41 only slight constructional changes in the gas sensor of claim 1, 12 and 40 are defined which come within the scope of the customary practice followed by persons skilled in the art (see documents D1 and D3-D10), especially as the advantages thus achieved can readily be foreseen.
Consequently, these dependent claims do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step.

Re Item VI

Certain documents cited

7.1 Document D2 (WO2004/023113) was cited in the search report as PX document. As claim 12 is considered to comprise features which were not disclosed in the priority document, document D2 is to be considered as prior art for this claim.

7.2 Document D2 shows in figure 4 a gas sensor comprising a cylindrical cavity (Page 7, lines 1-2) for containing a gas, means for generating radiation (2) and a detector (4) for detecting radiation, the tubular cavity having substantially planar end walls. The exact dimensions regarding the ratio of height to width are not given, although the figure points to equal dimensions. Claim 12 is therefore considered new in view of D2, but not inventive for the same reasons that claim 12 is not considered inventive in view of D1.

CLAIMS

1. A gas sensor comprising a cavity for containing a gas; means for generating radiation which is transmitted through the cavity and including one or more wavelengths which is absorbed in use by a gas to be detected; and a detector for detecting radiation which has passed through the cavity, the detector having a surface area which is visible to the interior of the cavity, the walls of the cavity being sufficiently reflective to the radiation that the cavity is substantially uniformally illuminated with the radiation, such that the visible surface area of the detector is illuminated with substantially unfocussed radiation, wherein the radiation generating means and/or detector(s) is mounted on a printed circuit board and is surrounded by resilient protection.

2. A sensor according to claim 1, wherein the resilient protection comprises a resilient member having one or more apertures through which the radiation generating means and/or respective detector(s) extends.

3. A sensor according to claim 2, wherein the radiation generating means and/or respective detector(s) extends in a close fitting relationship through the aperture(s).

4. A sensor according to the preceding claims, wherein the pcb and the components mounted thereon are located in an electronics housing having an upper wall, the upper surface of which defines a wall of the cavity.

5. A sensor according to any of claims 2 to 4, wherein the resilient member and electronics housing have complementary keying features which interengage.

6. A gas sensor according to any of the preceding claims, wherein the cavity comprises a first end wall adjacent to which at least one of the means for generating radiation and the detector is positioned, a second end wall which opposes the first end wall, and a side wall; the first and second end walls defining the height of the cavity between them and the width of the cavity being defined as a maximum

dimension of the cavity orthogonal to its height, wherein the ratio of the height to the width is greater than or equal to 0.1 and less than 1.

7. A gas sensor according to any of claims 1 to 5, wherein the cavity comprises a first end wall adjacent to which the means for generating radiation and the detector are positioned, a second end wall which opposes the first end wall, and a side wall; the width of the cavity being defined as the maximum dimension of the cavity along a line joining the means for generating radiation and the detector, and the height of the cavity being defined as the maximum dimension of the cavity in a direction orthogonal to its width, wherein the ratio of the height to the width is greater than or equal to 0.1 and less than 1.

8. A sensor according to claim 6 or claim 7, wherein the height to width ratio is greater than or equal to 0.2.

9. A sensor according to claim 8, wherein the height to width ratio is greater than or equal to 0.4.

10. A sensor according to claim 9, wherein the height to width ratio is greater than or equal to 0.5.

11. A sensor according to any of claims 6 to 10 wherein the height to width ratio is less than or equal to 0.7.

12. A gas sensor comprising a cavity for containing a gas; means for generating radiation which is transmitted through the cavity and including one or more wavelengths which is absorbed in use by a gas to be detected; and a detector for detecting radiation which has passed through the cavity, the detector having a surface area which is visible to the interior of the cavity, the walls of the cavity being sufficiently reflective to the radiation that the cavity is substantially uniformally illuminated with the radiation, wherein the cavity is tubular, for example cylindrical, and has substantially planar end walls, adjacent to at least one of which, at least one of the means for generating radiation and the detector is positioned and wherein the ratio of the height to the width of the cavity is greater than or equal to 0.1 and less than or equal to 0.7.

13. A sensor according to claim 12, wherein the height to width ratio is greater than or equal to 0.2.

14. A sensor according to claim 13, wherein the height to width ratio is greater than or equal to 0.4.

15. A sensor according to claim 14, wherein the height to width ratio is greater than or equal to 0.5.

16. A sensor according to any of claims 12 to 15, wherein the visible surface of the detector is illuminated with substantially unfocussed radiation.

17. A gas sensor according to any of the preceding claims, wherein the entire visible surface area of the detector is illuminated with substantially unfocussed radiation.

18. A gas sensor according to any of the preceding claims, wherein increasing the visible surface area of the detector relative to the surface area of the cavity walls increases the signal to noise ratio detected by the detector.

19. A sensor according to any of claims 12 to 18, wherein the radiation generating means and/or detector(s) is mounted on a printed circuit board and is surrounded by resilient protection.

20. A sensor according to claim 19, wherein the resilient protection comprises a resilient member having one or more apertures through which the radiation generating means and/or respective detector(s) extends.

21. A sensor according to claim 20, wherein the radiation generating means and/or respective detector(s) extends in a close fitting relationship through the aperture(s).

22. A sensor according to any of claims 19 to 21, wherein the pcb and the components mounted thereon are located in an electronics housing having an upper wall, the upper surface of which defines a wall of the cavity.

23. A sensor according to any of claims 20 to 22, wherein the resilient member and electronics housing have complementary keying features which interengage.

24. A sensor according to any of the preceding claims, wherein the radiation generating means generates infra-red

radiation.

25. A sensor according to claim 24, wherein the infra-red radiation generating means comprises a heating element to heat gas within the cavity so as to cause the gas to generate infra-red radiation.

26. A sensor according to any of claims 1 to 24, wherein the means for generating radiation comprises a filament bulb or LED(s).

27. A sensor according to any of the preceding claims, wherein the radiation generating means is located, at least partially, in the cavity.

28. A sensor according to any of the preceding claims, further comprising one or more additional radiation detectors, each detector being adapted to sense radiation centered on a respective, different wavelength.

29. A sensor according to any of the preceding claims, wherein the cavity wall defines a window allowing radiation to pass therethrough to the or a respective detector.

30. A sensor according to any of the preceding claims, wherein the cavity is substantially closed and has at least one aperture to allow passage of gas into and out of the cavity.

31. A sensor according to any of the preceding claims, wherein a majority, preferably more than 90%, of the cavity walls have a reflectivity to radiation exceeding 95%.

32. A sensor according to any of the preceding claims, wherein at least a portion of the cavity walls are provided with a reflective coating.

33. A sensor according to claim 32, wherein the reflective coating comprises gold plating.

34. A sensor according to any of the preceding claims, wherein the cavity walls are covered by a radiation transparent protective coating.

35. A sensor according to any of claims 1 to 11, wherein the cavity is tubular, for example cylindrical, and has substantially planar end walls.

36. A sensor according to any of the preceding claims,

wherein the cavity, means for generating radiation, and detector are located within an outer housing having at least one aperture to allow gas to enter.

37. A sensor according to claim 36, further comprising a flame arrestor within the outer housing.

38. A sensor according to claim 37, wherein the flame arrestor is secured to an outer surface of a housing having at least one aperture, the housing defining a wall of the cavity, by a flange which overlaps the flame arrestor whereby, when the cavity housing is assembled in the outer housing, the flange defines the thickness of a gas chamber communicating with the apertures in the outer and cavity housings.

39. A sensor according to any of claims 36 to 38, further comprising a memory such as an EEPROM, located within the outer housing for storing calibration data, the memory being coupled with electrical contacts such as pins accessible from outside the outer housing.

40. A method of constructing a gas sensor according to any of claims 1 to 39, the method comprising:

(a) inserting a tubular, optical housing, closed by a wall at one end except for at least one gas access aperture, into a tubular outer housing closed at its end adjacent the closed end of the optical housing, except for at least one gas access opening;

(b) inserting a radiation source and detector on a printed circuit board into a tubular electronics housing, the electronics housing having an end wall closed at one end except for one or more apertures to allow access to the source and detector;

(c) inserting the electronics housing into the outer housing so that it mates with the optical housing and defines therewith a substantially closed optical cavity between the end walls of the electronics and optical housings and in

which a gas to be sensed is located in use; and,

(d) securing the assembled housings together.

41. A method according to claim 40, wherein step d) comprises applying potting compound to the assembled housings.